Opportunities for Accelerator Mass Spectrometry at the HRIBF

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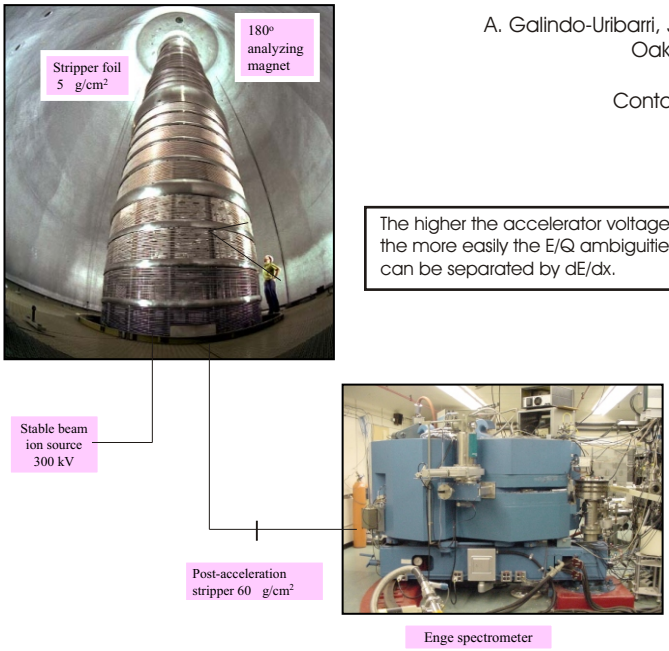
AMS systems have been used to measure isotopic ratios to a level of 1 in 10^{16}, many orders of magnitude better than most conventional spectrometers.



The higher the accelerator voltage, the more easily the E/Q ambiguities can be separated by dE/dx.

The United States has the highest operating voltage electrostatic accelerator in the world, the 25-MV Tandem from ORNL. We would like to investigate the feasibility of using the Tandem, as a prototype facility to aid in the development of new Accelerator Mass Spectrometry (AMS) methods with application to Stewardship Science. AMS is one of the analytical techniques with the highest sensitivity known in physics. The technique of AMS is used to perform ultra-sensitive measurements of concentration of rare isotopes in samples placed in the ion source of an accelerator system. A key advantage of the technique is that it requires only very small samples of material. The method consists of counting individual atoms that have been ionized, accelerated to high energies in a tandem Van de Graff accelerator, and then selected and identified. These radionuclides can be used for a wide variety of applications. The general goals of the project are to study the physics underlying the measuring process, to use this knowledge to optimize the method, and to make the technique applicable.

Fig 1 Main components for the setup for AMS tests at HRIBF

The necessary elements exist at ORNL to explore the establishment of an AMS program: HRIBF's 25-MV Tandem accelerator, negative ion-source technology, mass spectrometry, detector development, and research interests. The unique facility offers exciting opportunities as a prototype facility to aid in the development of new AMS methods. Atmospheric and underground nuclear weapons tests have introduced into the environment a variety of long-lived radionuclides. Other nuclear activities, including fuel reprocessing and waste disposal have contributed as well. To limit the proliferation of nuclear weapons manufacture and testing requires the highest sensitivity techniques possible to detect radionuclides in the environment that serve as a signature of clandestine activities. AMS measurements of ^{36}Cl together with ^{129}I can offer a valuable tool to monitor safeguard policies. AMS can also be used for the characterization of weapons grade material via the determination of ^{240}Pu/^{239}Pu ratios.

Unique Characteristics:

* Highest operating voltage electrostatic accelerator in the world.
  => Production of fully-stripped ions up to about A~60, =1%.
* Folded geometry
  => Breakup of molecules and rejection of unwanted species at early stage.
* Both RIB's and AMS will benefit from development of techniques and solving common problems.

AMS & RIBs common problems/needs:

* Isobar separation
* Low intensity beam diagnostics
* High intensity sources
* Good transmission
* Good detection tools
  - Bragg Detector
  - Projectile X-ray
  - TOF
  - Gas-filled magnet

Current effort:
Proof of principle
^{36}Cl ($t_{1/2}$ = 3.01 x 10^6 a)
Seawater samples:
Barents, Atlantic, Nova Scotia.
(^{36}Cl/Cl ~ 3 x 10^{-15})

Future:
^{36}Cl applications (release of radioactivity from fuel reprocessing plants, reactors, and radioactive waste disposal sites).
^{14}C "Old C project"
Fission fragments and actinides (^{99}Tc, ^{129}I, Pu, . . .)

AMS at HRIBF First Results

Efficient elimination of isobars with smaller Z than the species of interest is possible by fully stripping after acceleration but prior to final energy analysis.

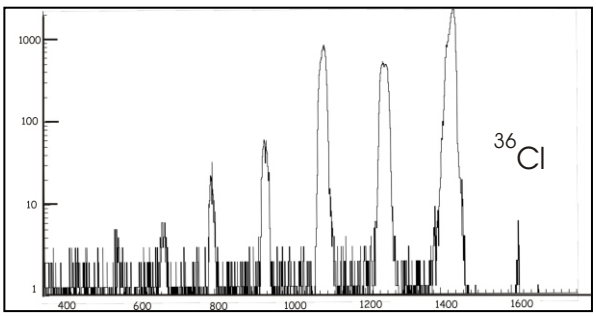


Fig. 2 Spectrum of a ^{36}Cl sample from Atlantic Sea (4 km), showing excellent separation from ^{36}S contamination.